

**The genetic structuring of Atlantic salmon (*Salmo salar* L.)
populations in northwest Europe as revealed through nuclear
microsatellite and mtDNA PCR-RFLP analysis:**

From regional to catchment level analysis and its application in
conservation and management of the species.

In the style of the Journal of Fish Biology.

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ABSTRACT

The structuring of Atlantic salmon (*Salmo salar* L.) into discrete, genetically differentiated populations both within and between river catchments is well documented. The utilisation of this knowledge has proved valuable in a variety of evolutionary, ecological, managerial and conservation contexts. In this thesis, the genetic structuring of Atlantic salmon populations in northwest Europe was assessed in two catchments of very different sizes, using a range of molecular and associated population genetic methods; findings from the catchment level research are set in context by a broader phylogeographic study of post-glacial colonisation of the region.

A regional study into the glacial origins and post-glacial colonisation routes of Atlantic salmon in northwest Europe was explored by analysing a pre-existing microsatellite dataset and supplementing it with haplotype data from mtDNA PCR-RFLP analysis of the same samples (N=702). Evidence from allele permutation tests undertaken on the microsatellite data alongside mtDNA haplotype frequencies suggested that there was a cryptic northern refuge in northwest France, with colonisation of the British Isles and Ireland occurring from this and the long-known Iberian Peninsula refuge.

Catchment level studies were undertaken on the river Dart and river Tweed, involving 1151 fish being genotyped with 14 microsatellite loci with a subset of 211 fish being genotyped by mtDNA PCR-RFLP. In both catchments, populations were found to be weakly differentiated genetically, and were most consistent with the meta-population theory of evolution. Similarly, individual spatial autocorrelation analysis indicated that each major tributary within the catchments could be considered as a distinct management or conservation unit. In the Tweed dataset, however, limitations in the sample coverage across the catchment reduced the robustness of some findings.

Historical stocking of the river Dart with fish from Scotland and Iceland is well-documented. The long-term implications of these activities on contemporary Dart populations were assessed by genotyping 177 fish from the donor populations using scale samples taken in the 1960s and comparing them to contemporary Dart populations by undertaking admixture analysis. Overall, admixture between the

donor and recipient populations was low and appeared to reflect natural underlying levels of genetic relationships. However, increased admixture of donor stocks with one extant Dart population was apparent, indicating some potentially long-term localised success of the stocked fish through hybridisation with the native populations; nevertheless, with the population continuing to decline, this should not be viewed as a successful supplementation programme.

Two tributaries on the river Tweed, the Gala and Leader, were inaccessible to salmon for long periods due to the construction of barriers to migration. On both tributaries, fish passes were installed in the 1940s and re-colonisation of the tributaries was possible. Assignment analysis was undertaken and indicated that, contrary to findings for between catchment studies, salmon straying from the most proximate tributaries (i.e. the Ettrick and Caddon) did not appear to be the principal colonisers of the current Gala and Leader populations. Rather, the highest proportion of Gala samples assigned to the Teviot (42%), with the Leader populations assigning to many tributaries across the catchment (Ettrick 28%; Upper 21%; Teviot 19%). However, given the relatively weak differentiation of the baseline samples and limitations inherent in the dataset, the correct self-assignment of baseline samples was very low (average 26%; range 0-47%), hence interpretation must be undertaken with caution. Nevertheless, the findings suggest that the Gala population may have reached a temporally stable state in the 60 years since it has been accessible to salmon.

Whilst the relatively small scale of these studies is acknowledged, the application of the findings in management and conservation of the species are discussed in a wider context. These studies would support the following recommendations: to include information on the historic (refugial) origin of contemporary populations in regional management strategies; to treat each major tributary as a distinct unit as an appropriate scale for catchment level management; and, with stocking and supplementation programmes appearing to have no significant long-term success, coupled with the relative speed with which extirpated tributaries appear to be naturally re-colonised, the use of stocking and supplementation programmes should be discouraged.

TABLE OF CONTENTS

Abstract.....	2
List of Figures.....	11
List of Tables.....	13
Acknowledgements.....	15
Chapter 1: Introduction.....	17
Global distribution.....	17
Life history.....	19
Life in freshwater.....	19
Parr-Smolt transformation.....	21
Timing.....	22
Morphological and physiological changes.....	22
Olfactory imprinting.....	23
Sexual maturation.....	23
Life at sea.....	24
Migration and homing.....	26
Anthropogenic influences on Atlantic salmon populations.....	27
Current genetic characterization.....	30
Inter-species level.....	30
Intra-species level.....	32
Genetic differentiation within catchments.....	42
Characterisation methods.....	45
Allozymes.....	46
Restriction Fragment Length Polymorphisms (RFLPs).....	46
Minisatellites.....	47
Microsatellites.....	47
RAPDs, ISSRs, IRAPs, AFLPs.....	47

Single nucleotide polymorphisms (SNPs).....	48
DNA sequencing.....	48
Overall Objectives of the Thesis.....	49
Unravelling the phylogeographic history of Atlantic salmon in northwest Europe (Chapter 3).....	49
Within river structuring of Atlantic salmon populations (Chapters 4 and 6).....	50
Assessing the impact of anthropogenic activities on within river Atlantic salmon populations.....	52
Chosen markers: Microsatellites.....	53
Chapter 2: Methods.....	55
Study area catchment details.....	55
River Dart.....	55
River Tweed.....	57
Sample collection.....	59
River Dart.....	59
River Tweed.....	61
Historical scale samples.....	63
Phylogeography.....	65
Methodological development.....	66
DNA extractions.....	66
Microsatellites.....	68
mtDNA RFLP.....	70
Assessing the behaviour and power of molecular markers.....	72
Linkage and selection.....	72
Assessing anomalous findings.....	73
Ssa171.....	73

Salmon-trout hybrid tests.....	73
Chapter 3: Use of multiple markers demonstrates cryptic northern refugia and postglacial colonisation routes of Atlantic salmon (<i>Salmo salar</i> L.) in northwest Europe.....	74
Introduction.....	75
Methods.....	79
Sample collection.....	79
DNA analysis: Microsatellite.....	79
DNA analysis: mtDNA RFLP.....	79
Microsatellite data analyses.....	80
PCR-RFLP mtDNA data analyses.....	82
Results.....	83
Microsatellite data analyses.....	83
mtDNA RFLP data analysis.....	94
Discussion.....	97
Genetic diversity and differentiation.....	97
Refugial locations for Atlantic salmon in northwest Europe.....	98
Colonisation of Britain and Ireland.....	100
Conclusions.....	102
Chapter 4: Tributary level structuring of Atlantic salmon (<i>Salmo salar</i> L.) populations within a small river catchment: implications for conservation and management.....	103
Introduction.....	104
Methods.....	108
Sample collection.....	108
DNA analysis: Microsatellite.....	108
DNA analysis: mtDNA RFLP.....	108

Statistical analysis: Assessing the impact of post-glacial colonisation processes in determining population structuring.....	109
Statistical analysis: Assessing the role of metapopulation and member-vagrant evolutionary models in determining population structuring (Microsatellite analysis).....	110
Results.....	113
Assessing the impact of post-glacial colonisation processes in determining population structuring	113
Assessing the role of metapopulation and member-vagrant evolutionary models in determining population structuring.....	116
Discussion.....	128
Genetic diversity and divergence within the river Dart.....	128
Influence of phylogeographic history on contemporary population structuring.....	129
Temporal variation within the river Dart.....	129
Spatial variation within the river Dart.....	130
Role of evolutionary models acting to maintain within river genetic structuring.....	131
Management and conservation considerations.....	133
 Chapter 5 Assessing the long-term genetic impact of historical stocking events on contemporary populations of Atlantic salmon (<i>Salmo salar</i> L.).....	134
Introduction.....	135
Methods.....	139
Sample collection.....	139
Genetic analysis.....	139
Data analysis.....	140
Results.....	142
Population Genetic Parameters.....	142
Assessing genetic relationships between donor and recipient stocks	148

Discussion.....	150
Estimates of underlying historical genetic relationships.....	150
Continued impact of Icelandic fish in the Dart.....	151
Continued impact of Scottish fish in the Dart.....	151
Variations between tributaries.....	152
Implications for management	153
Conclusions.....	154
 Chapter 6: The genetic structuring of Atlantic salmon populations in the river Tweed: implications for management and conservation.....	156
Introduction.....	157
Methods.....	162
Sample collection.....	162
DNA analysis.....	162
Assessing spatial genetic structure.....	162
Spatial autocorrelation analysis.....	168
Results.....	169
Assessing spatial genetic structure.....	169
Analysis of inferred populations.....	170
Spatial autocorrelation analysis.....	175
Discussion.....	180
Limitations associated with the inference of populations.....	180
Genetic diversity and divergence of inferred populations of the river Tweed.....	181
Spatial variation of Atlantic salmon populations within the river Tweed.....	182
Role of evolutionary mechanisms acting to maintain genetic structuring within the Tweed.....	183

Implications for management and conservation of Atlantic salmon populations in the Tweed.....	184
Conclusions.....	185
 Chapter 7: Re-colonisation of two tributaries of the Tweed by Atlantic salmon after more than 120 years of obstruction.....	186
Introduction.....	187
Methods.....	191
Data analysis.....	191
Results.....	193
Discussion.....	198
Limitations of the baseline dataset.....	198
Origin of Gala and Leader populations.....	198
Genetic differentiation of Gala and Leader populations.....	199
Temporal stability of the Gala populations.....	200
Implications for management and conservation of Tweed salmon.....	200
 Chapter 8: General discussion.....	203
Unravelling the phylogeographic history of Atlantic salmon in northwest Europe.....	203
Within river structuring of Atlantic salmon populations.....	204
Limitations of the dataset.....	205
Assessing the impact of anthropogenic activities on within river Atlantic salmon populations.....	207
Potential improvements and additional avenues of related research.....	210
Conclusions.....	211
 References.....	212

LIST OF FIGURES

Figure 1.1 Atlantic salmon distribution.....	18
Figure 1.2 Life cycle of the Atlantic salmon.....	20
Figure 1.3 Total nominal catches of Atlantic salmon, 1960-2007.....	27
Figure 1.4 Phylogeny of Salmoninae (Family: Salmonidae).....	32
Figure 1.5 Genetic distance phenogram depicting the division between North America and Europe, generated from microsatellite data.....	33
Figure 1.6 UPGMA clustering of Atlantic salmon populations, depicting divergence between salmon from the Atlantic and Baltic drainages.....	34
Figure 1.7 Proposed refugial locations for Atlantic salmon during the last glacial period and colonisation routes subsequent to deglaciation.....	38
Figure 1.8 Member-Vagrant model maintaining population structuring within catchments, characterised by low migration between populations.....	43
Figure 1.9 Meta-population model maintaining population structuring within catchments, characterised by extinction-recolonisation events and therefore increased migration.....	44
Figure 2.1 Net and rod catches for Atlantic salmon on the river Dart, 1951-2004...	56
Figure 2.2 Rod catches of Atlantic salmon on the river Tweed, 1914-2006.....	58
Figure 2.3 Sampling locations on the river Dart. Details follow Table 2.1.....	60
Figure 2.4 Sampling locations on river Tweed. Details follow Table 2.2.....	61
Figure 2.5 Sampling locations for stocking analysis. For details refer to Table 2.3.....	64
Figure 2.6 Samples available from the ASAP project for phylogeographic analysis. Details follow Table 2.4.....	65
Figure 2.7 RFLP haplotypes of the ND1 region of mtDNA.....	71

Fig. 3.1 Neighbour Joining phylogenetic tree of Atlantic salmon populations across northwest Europe generated from microsatellite data.....	91
Figure 3.2 STRUCTURE output depicting 5 regional groups of Atlantic salmon populations across northwest Europe.....	91
Figure 3.3 Allele size permutation test results testing whether stepwise mutations of microsatellite regions have contributed to the genetic differentiation among the five regions of northwest Europe depicted in the STRUCTURE analysis and phylogenetic tree.....	93
Figure 3.4 Geographical distribution of mtDNA haplotype frequencies for Atlantic salmon across northwest Europe.....	95
Figure 3.5 UPGMA phylogenetic tree generated from mtDNA RFLP data depicting relationships between matrilineal populations of Atlantic salmon across northwest Europe.....	96
Figure 4.1 UPGMA phylogenetic tree from mtDNA RFLP analysis of river Dart populations.....	114
Figure 4.2 UPGMA phylogenetic tree from mtDNA RFLP analysis.....	115
Figure 4.3 Neighbour Joining phylogenetic tree of salmon populations from the river Dart using microsatellite analysis.....	124
Figure 4.4 Isolation by distance of all Dart populations (all diamonds) and of upper Dart populations only (no Hems; grey diamonds only).....	126
Figure 4.5 Genetic autocorrelation analysis of individual Dart salmon at different distance classes.....	126
Figure 4.6 Genetic autocorrelation analysis of individual Dart salmon for increasing distance classes.....	127
Figure 6.1 A Neighbour-Joining population tree based on Nei's (1987) DA distance between inferred populations.....	176

Figure 6.2 Genetic autocorrelation analysis of individual Tweed salmon at different distance classes.....	178
Figure 6.3 Genetic autocorrelation analysis of individual Tweed salmon genetic structure for increasing distance classes.....	179
Figure 7.1 The Gala Cauld (Weir) after being rebuilt in the 1940s with fishpass...	189
Figure 7.2 One of three obstructions to fish passage on the Leader.....	189

LIST OF TABLES

Table 2.1 Sample details for the river Dart.....	60
Table 2.2 Sample details for the river Tweed.....	62
Table 2.3 River locations for stocking analysis.....	64
Table 2.4 Samples available from the ASAP project for phylogeographic analysis.....	65
Table 2.5 Details of microsatellites used.....	69
Table 3.1 Genetic diversity indices for microsatellite data, mtDNA RFLP data and mtDNA RFLP haplotype frequencies.....	84
Table 3.2 Microsatellite diversity indices by population.....	85
Table 3.3 Genetic divergence of populations.....	89
Table 3.4 Regional genetic diversity indices.....	92
Table 4.1 mtDNA RFLP results and diversity indices.....	113
Table 4.2 Microsatellite diversity indices for the river Dart by population.....	117
Table 4.3 Genetic differentiation (pairwise F_{ST}) and geographic separation (km) of Dart populations.....	121
Table 4.4 Self-assignment of Dart populations.....	122
Table 5.1 Microsatellite diversity indices by population.....	144
Table 5.2 Genetic differentiation of populations as estimated with pairwise F_{ST} between Atlantic salmon samples.....	147
Table 5.3 Results from admixture analysis (Q) carried out using STRUCTURE; Donor populations (Tweed, Tay, Ellidaar) pre-defined geographically.....	149
Table 5.4 Results from admixture analysis (Q) carried out using STRUCTURE; Recipient populations (Dart) defined geographically.....	149

Table 6.1a – 6.1g Groupings of samples defined in the hierarchical gene diversity analyses for each tributary and the whole catchment, with percentages of variance explained within and between groupings (see legend for full details).....	164
Table 6.2 Diversity indices at each microsatellite loci for inferred populations (see Table 6.1g).....	171
Table 6.3 Population differentiation estimates; pairwise F_{ST} estimates (below diagonal) with associated p-value above diagonal.....	174
Table 6.4 Number (percent) of individuals assigned to inferred populations and full tributary of origin (Trib).....	177
Table 7.1 Self assignment of baseline Tweed populations; number (percentage)...	194
Table 7.2 Assignment of Gala samples to baseline Tweed populations.....	195
Table 7.3 Assignment of Leader samples to baseline Tweed samples.....	196

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